# Proposal for a new Supplement to the 06 series of amendments to UN Regulation No. 49 (Emissions of compression ignition and positive ignition (LPG and CNG) engines)

## Submitted by the expert from the International Organization of Motor Vehicle manufacturers

The text reproduced below was prepared by the expert from OICA to correct the improper or confusing provisions described in current text of 06 series of amendments to UN Regulation No.49.

In the Part 1) the modifications (essentially corrections of mistakes) are derived from the text of document ECE/TRANS/WP.29/GRPE/2021/7 from Japan, related to UN GTR 04, as modified by Informal Document GRPE-82-09

Other modifications are proposed by OICA experts in the Part 2).

The modification of the current text of UN R49.06 are marked in bold for new or strikethrough for deleted characters.

# I. Proposal

***Part 1) - Amendments to ANNEX 4, in line with Japanese document ECE/TRANS/WP.29/GRPE/2021/7 as modified by Informal Document GRPE-82-09***

*Paragraph 8.4.2.3., Equation (36),* amend to read:

"8.4.2.3. Calculation of mass emission based on tabulated values

$$m_{gas} = u_{gas} \times \sum_{i=1}^{i=n} \left( c_{gas,i} \times q_{mew,i} \times \frac{1}{f} \right) \quad in\ (g/test) \qquad (36)$$

..."

*Paragraph 8.4.2.4., Equation (37),* amend to read:

"8.4.2.4. Calculation of mass emission based on exact equations

$$m_{gas} = \sum_{i=1}^{i=n} \left( u_{gas,i} \times c_{gas,i} \times q_{mew,i} \times \frac{1}{f} \right) \quad in\ (g/test) \qquad (37)$$

..."

*Paragraph 8.5.1.4., Equation (54),* amend to read:

"8.5.1.4. SSV-CVS system

…

$$Q_{SSV} = \frac{A_0}{\mathbf{60}} d_V^2 C_d p_p \sqrt{\left[ \frac{1}{T} \left( r_p^{1.4286} - r_p^{1.7143} \right) \cdot \left( \frac{1}{1 - r_D^4 r_p^{1.4286}} \right) \right]} \qquad (54)$$

Where:

$A_0$ is **0.005692** ~~0.006111~~ in SI units of $\left(\frac{m^3}{min}\right)\left(\frac{K^{\frac{1}{2}}}{kPa}\right)\left(\frac{1}{mm^2}\right)$

$d_V$ is the diameter of the SSV throat, **mm**~~m~~

…"

*Paragraph 8.5.2.3.1., Equation (57),* amend to read:

"8.5.2.3.1. Systems with constant mass flow

…

$$u_{gas} = \frac{M_{gas}}{M_d \times \left(1 - \frac{1}{D}\right) + M_e \times \left(\frac{1}{D}\right)} \times \frac{\mathbf{1}}{\mathbf{1000}} \quad (57)$$

…"

*Paragraph 8.6.1.,* amend to read:

"8.6.1. Drift correction

Depending on the measurement system and calculation method used, the uncorrected emissions results shall be calculated with equations 36, 37, 56, ~~57~~ **58** or 62, respectively. For calculation of the corrected emissions, $c_{gas}$ in equations 36, 37, 56, ~~57~~ **58** or 62, respectively, shall be replaced with $c_{cor}$ of equation 66. If instantaneous concentration values $c_{gas,i}$ are used in the respective equation, the corrected value shall also be applied as instantaneous value $c_{cor,i}$. In equation **58, and 62,** the correction shall be applied to both the measured and the background concentration. …"

*Paragraph 9.5.4.1., Equation (89) and (90),* amend to read:

"9.5.4.1. Data analysis

…

$$C_d = \frac{Q_{ssv}}{\frac{\boldsymbol{A_0}}{\mathbf{60}} \times d_V^2 \times p_p \times \sqrt{\left[\frac{1}{T} \times \left(r_p^{1.4286} - r_p^{1.7143}\right) \times \left(\frac{1}{1 - r_D^4 \times r_p^{1.4286}}\right)\right]}} \quad (89)$$

...

*dV is the diameter of the SSV throat,* ~~*m*~~***mm***

…

$$Re = A_1 \times \mathbf{60} \times \frac{q_{SSV}}{d_V \times \mu} \quad (90)$$

...

Where:

*$A_1$ is* ***27.43831*** ~~*25.55152*~~ *in SI units of* $\left(\frac{\mathbf{kg}1}{m^3}\right)\left(\frac{min}{s}\right)\left(\frac{mm}{m}\right)$

*$Q_{SSV}$ is the airflow rate at standard conditions (101.3 kPa, 273 K), m3/s*

*$d_V$ is the diameter of the SSV throat,* ~~*m*~~***mm***

*…"*

*Paragraph A.2.1.3.,* amend to read:

"A.2.1.3. Components of Figures 9 and 10

EP Exhaust pipe

SP**1** Raw exhaust gas sampling probe (Figure 9 only)

…"

Submitted by the expert from OICA

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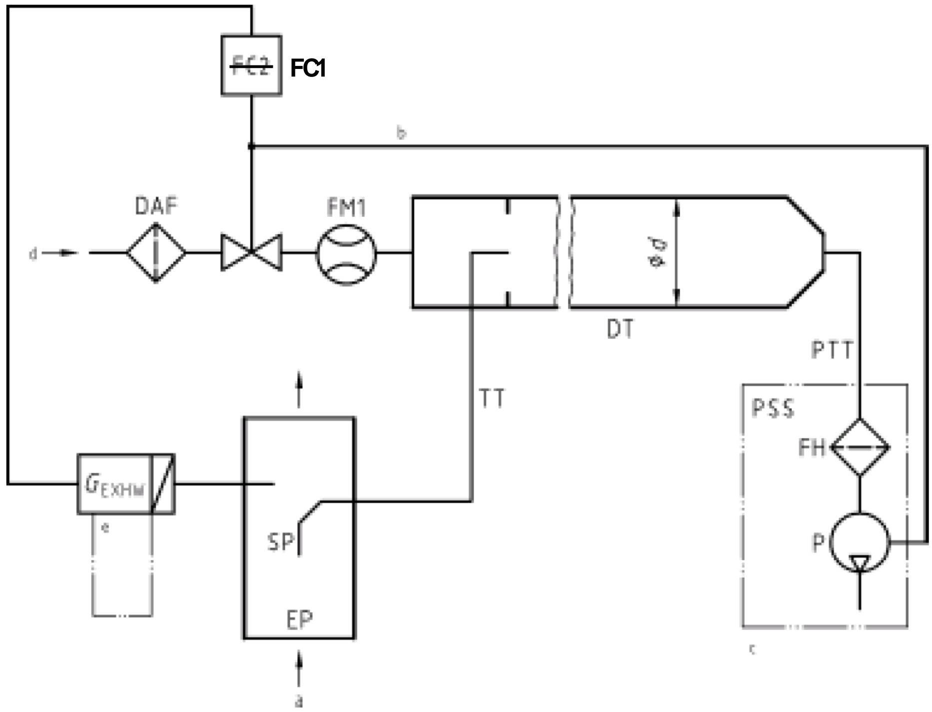
*Paragraph A.2.2.1. Figure 12,* amend to read:

"Figure 12
**Scheme of partial flow dilution system (total sampling type)**




a = exhaust b = optional c = details see Figure 16

…"

*Paragraph A.2.2.5.,* amend to read:

"A.2.2.5. Description of particulate sampling system

…

For a partial flow dilution system, a sample of the diluted exhaust gas is taken from the Dilution Tunnel (DT) through the Particulate Sampling Probe (PSP) and the Particulate Transfer Tube (PTT) by means of the sampling pump P, as shown in Figure 16. The sample is passed through the Filter Holder(s) (FH) that contain the particulate sampling filters. The sample flow rate is controlled by the flow controller ~~FC3~~**FC2**.

For of full flow dilution system, a double dilution particulate sampling system shall be used, as shown in Figure 17. A sample of the diluted exhaust gas is transferred from the Dilution Tunnel (DT) through the Particulate Sampling Probe (PSP) and the Particulate Transfer Tube (PTT) to the Secondary Dilution Tunnel (SDT), where it is diluted once more. The sample is then passed through the Filter Holder(s) (FH) that contain the particulate sampling filters. The diluent flow rate is usually constant whereas the sample flow rate is controlled by the flow controller ~~FC3~~**FC2**. If Electronic Flow Compensation (EFC) (see Figure 15) is used, the total diluted exhaust gas flow is used as command signal for ~~FC3~~**FC2**.

…"

***Part 2) – Further amendments to ANNEX 4 not included in the document ECE/TRANS/WP.29/GRPE/2021/7***

*Paragraph 8.2.,* amend to read:

"8.2. NOx correction for humidity

As the NOx emission depends on ambient air conditions, the NOx concentration shall be corrected for humidity with the factors given in paragraph 8.2.1. or 8.2.2. The intake air humidity Ha may be derived from relative humidity measurement, dew point measurement, vapour pressure measurement or dry/wet bulb measurement using generally accepted equations.

**For all humidity calculations (for example Ha, Hd) using generally accepted equations the saturation vapour pressure is required. For calculating the saturation vapour pressure which is in general a function of the temperature (at the humidity measurement point) the equation D.15 specified in Annex D to ISO Standard 8178-4 should be used."**

*Paragraph 9.2., Table 7,* amend to read:

"Table 7

**Linearity requirements of instruments and measurement systems**

| *Measurement system* | *χmin* X (*a1* - 1)+ *a0*\ | *Slope a1* | *Standard error SEE* | *Coefficient of Determination r2* |
|---|---|---|---|---|
| Engine speed | ≤ 0.05 % max | 0.98 - 1.02 | ≤ 2 % max | ≥ 0.990 |
| Engine torque | ≤ 1 % max | 0.98 - 1.02 | ≤ 2 % max | ≥ 0.990 |
| Fuel flow | ≤ 1 % max | 0.98 - 1.02 | ≤ 2 % max | ≥ 0.990 |
| Airflow | ≤ 1 % max | 0.98 - 1.02 | ≤ 2 % max | ≥ 0.990 |
| Exhaust gas flow | ≤ 1 % max | 0.98 - 1.02 | ≤ 2 % max | ≥ 0.990 |
| Diluent flow | ≤ 1 % max | 0.98 - 1.02 | ≤ 2 % max | ≥ 0.990 |
| Diluted exhaust gas flow | ≤ 1 % max | 0.98 - 1.02 | ≤ 2 % max | ≥ 0.990 |
| Sample flow | ≤ 1 % max | 0.98 - 1.02 | ≤ 2 % max | ≥ 0.990 |
| ~~**Gas analyzers**~~ **Gas dividers** | ≤ 0.5 % max | 0.99 - 1.01 | ≤ 1 % max | ≥ 0.998 |
| ~~**Gas dividers**~~ **Gas analyzers** | ≤ 0.5 % max | 0.98 - 1.02 | ≤ 2 % max | ≥ 0.990 |
| Temperatures | ≤ 1 % max | 0.99 - 1.01 | ≤ 1 % max | ≥ 0.998 |
| Pressures | ≤ 1 % max | 0.99 - 1.01 | ≤ 1 % max | ≥ 0.998 |
| PM balance | ≤ 1 % max | 0.99 - 1.01 | ≤ 1 % max | ≥ 0.998 |
| **Humidity measurement device** | **≤ 2 % max.** | **0.98 – 1.02** | **≤ 2 %** | **≥ 0.95** |

"

Reasonings:
1) Regulation 49 defines no linearity requirements for humidity sensors. As the humidity content of the intake air is an essential measure for the calculation of the specific exhaust emission, it is important to add requirement for humidity sensor.

Reference:
ISO 16183 the accuracy of the absolute humidity shall be +- 5%.

2) As the gas divider is a necessary tool to verify the linearization of the gas analyzer it is mandatory that the deviation of the gas divider is lower than that of the instrument under test. In combination with a calibration gas which has an accuracy of 1 % and a gas divider, which has an accuracy of 1 % it is only possible to reach a guaranteed analyzer accuracy of 2 %. This is confirmed in chapter 9.3.1.2 by the required analyzer accuracy of 2%. According to these, it is obvious, that in lines 10 and 11 of In Table 7 of Annex 4 Chapter 9.2 the linearity requirements for gas dividers and gas analyzers are reversed.

*Paragraph 9.3.3.1.,* amend to read:

"9.3.3.1 Pure gas

Hydrogen~~-helium~~-mixture (FID burner fuel)
(40 ± 1 per cent hydrogen, balance helium **or alternatively nitrogen, or argon**)
(Contamination ≤1 ppm C1, ≤400 ppm CO2)"

*Paragraph 9.3.6.7. and 9.3.6.8.,* amend to read:

"9.3.6.7. Deactivation of the ozonator

The ozonator is now deactivated. The mixture of gases described in paragraph 9.3.6.6. passes through the converter into the detector. The indicated concentration (*b*) shall be recorded (the analyzer is in the NOx mode).

9.3.6.8. NO**x** mode
~~Switched to~~ **Keeping** NO**x** mode with the ozonator deactivated, the flow of oxygen or synthetic air shall be shut off. The NOx reading of the analyzer shall not deviate by more than ±5 per cent from the value measured according to paragraph 9.3.6.2. (the analyzer is in the NO**x** mode)."

Reasonings:
Typo error, the instrument should be now in NOx mode.

*Paragraph 9.3.6.2.,* amend to read:

"9.3.6.2. Calibration

The CLD and the HCLD shall be calibrated in the most common operating range following the manufacturer's specifications using zero and span gas (the NO content of which shall amount to about 80 per cent of the operating range and the NO2 concentration of the gas mixture to less than 5 per cent of the NO concentration). **With the ozonator deactivated**, the NOx analyzer shall be in the NO mode so that the span gas does not pass through the converter. The indicated concentration has
to be recorded."

Reasonings:
To clarify the operation procedure, make the text easier to be understood.

# II. Justification

## For Part 1)

1. Paragraph 8.4.2.3. /8.4.2.4.

In equations (36) and (37), all the calculation equations after Sigma need to be performed in Sigma. Therefore, parentheses are added to calculations after sigma.

2. Paragraph 8.5.1.4.

In the dimension of the volume flow equation, the coefficient $A_0$ must be divided by 60. Similarly, the coefficient $A_0$ must be 0.005692 in the standard conditions (273K, 101.3kPa). In addition, the unit of the SSV throat diameter $d_V$ must be (mm).

3. Paragraph 8.5.2.3.1.

Equation (57) needs to be multiplied by 1/1000 to adjust the number of digits. The number of digits is correctly adjusted in the equations (38) and (39), and the number of digits is similarly adjusted in the equation (57).

4. Paragraph 8.6.1.

In the text, the equation to be referenced is incorrect. It is equation (58) that needs to be referenced.

5. Paragraph 9.5.4.1.

The discharge coefficient of the SSV needs to be correlated with the SSV mass flow rate calculation formula. Therefore, the coefficient $A_0$ divided by 60 is added. In addition, the unit of the SSV throat diameter $d_V$ must be (mm).

Reynolds number must be multiplied by 60. The coefficient $A_1$ must be 27.43831 in the standard state (273K, 101.3kPa). In addition, the coefficient $A_1$ needs (kg) when converted to SI units.

6. Paragraph A.2.1.3.

In Figure 9, raw exhaust gas sampling probe is represented by “SP1”, whereas “SP” is indicated in the text. Therefore, it is necessary correctly set “SP1” in the text.

7. Paragraph A.2.2.1.

In the text, the flow controller is represented by “FC1”, whereas in Figure 12, it is “FC2”. Therefore, it is necessary to correctly set “FC1” in Figure 12.

8. Paragraph A.2.2.5.

In Figure 16 and Figure 17, the sample flow controller is represented as “FC2”, whereas in the text, it is “FC3”. Therefore, it is necessary correctly set “FC2” in the text.

## For Part 2)

See the reasoning below each proposed modification.